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Impact of fertilizers and irrigation interval as well as methods on incidence of aphid and whitefly in Bt cotton

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Abstract
Field experiment was conducted to study the impact of fertilizers and irrigation on incidence of aphid and whitefly in Bt cotton at Instructional Farm, College of Agriculture, Junagadh Agricultural University, Junagadh during Kharif, 2018. In case of nitrogenous fertilizer, lowest aphid index and whitefly population was recorded in nitrogen level N_1 (180 kg /ha). Whereas, in case of phosphorus fertilizer, lowest aphid index and whitefly population was recorded in phosphorus level P_3 (75 kg P_2O_5 /ha). Moreover, Lowest mean aphid index and mean whitefly population was recorded in the treatment combination of N_1P_3 [180 kg N/ha + 75 kg P_2O_5/ha] and N_1P_2 [180 kg N/ha + 50 kg P_2O_5/ha], respectively. In case of irrigation intervals and methods, for aphid population, I_3 (21 days irrigation interval) and M_2 (Ridge and Furrow) registered significantly lowest aphid index. While, best treatment combination was I_1M_2 [7 days interval + Ridge and Furrow] that found lowest aphid population. For whitefly, I_3 (21 days irrigation interval) and M_2 (Ridge and furrow) recorded lowest whitefly population. Moreover, best treatment combination was I_3M_2 (21 days + Ridge and furrow) and found lowest whitefly population. The highest cotton yield found in plots of N_3P_2 [300 kg N/ha + 50 kg P_2O_5/ha]. The aphid and whitefly incidence declined with decreased nitrogenous fertilizer level as well as increased phosphorus fertilizer level.

Keywords: Aphid, whitefly, irrigation, fertilizers, yield, Bt-cotton

Introduction
In India, cotton crop was grown over an area of 124.29 lakh ha with a production of 370 lakh bales and productivity 506 kg/ha. It is a pride of place in the farming of Gujarat's Agriculture. The economy of the entire state is very much dependent on success or failure of this cash crop. In Gujarat, cotton crop was grown over an area of 26.23 lakh ha with a production of 104.00 lakh bales and productivity 674.00 kg/ha (Anonymous, 2018) [2]. In India, approximately 162 species of insect pests and 4 mite species have been reported to attack the cotton crop right from germination till the final harvesting of cotton crop. (Anonymous, 2016) [1]. Among these pests, few of them are considered as major /key pests causing great per cent damage to cotton crop all over country, which results in an annual loss up to 20 to 80 per cent of the total production (Thakare *et al.*, 1983) [10]. Among different pests of cotton, aphid and whitefly having heavy incidence and cause serious damage on crop. Most important sucking pest of cotton is a hemipteran pest, aphid, *Aphis gossypii* (Glover) belongs to the family Aphididae have sucking type of mouth parts which cause infesting tender shoots and under surface of the leaves. Curling and crinkling of leaves stunted growth. Blighted appearance when infestation is severe. Development of black sooty mould due to the excretion of honey dew giving the plant a dark appearance. Second important sucking pest is Whitefly, *Bemisia tabaci* (Gennadius) belongs to the order Hemiptera and family Aleyrodidae. It causes chlorotic spots on the leaves which latter coalesce forming irregular yellowing of leaf tissue which extends from veins to the outer edges of the leaves. Severe infestation results in premature defoliation and cause the development of sooty mould, shedding of buds and bolls and poor boll opening. It also transmits the leaf curl virus diseases of cotton. Now a days, farmers are using injudicious fertilizers and inappropriate application of irrigation water that causing serious problems of pests and diseases in crop. Therefore, it is essential to know the effect of fertilizers and irrigation on cotton whitefly and aphid which helps in devising suitable management strategies.

Materials and Method

An experiment for impact of fertilizers was laid out in a FRBD with three levels of nitrogenous fertilizer and three levels of phosphorus fertilizer (N1: 180 kg N/ha, N2: 240 kg N/ha, N3: 300 kg N/ha and P1: 25 kg P_2O_5/ha, P2: 50 kg P_2O_5/ha, P3: 75 kg P_2O_5/ha). For impact of irrigation interval and method experiment was laid in a Strip plot design with three levels of irrigation interval (I_1: 7 days, I_2: 14 days, I_3: 21 days) and three methods of irrigation (M_1: Flat bed, M_2: Ridge and furrow, M_3: Alternate furrow). In both experiment, taken nine treatments with three replications having spacing of 120 cm × 45 cm and gross plot size of 6.0 m × 5.4 m during Kharif, 2018 at at Instructional Farm, College of Agriculture, Junagadh Agricultural University, Junagadh. The Bt cotton [RCH-2 (BG –II)] was raised after following standard agronomic practices. Experimental area was kept free from insecticidal spray.

Table 1: Treatments details:

Details of the treatments for fertilizer:			Details of the treatment for irrigation:		
Treatment	**N(kg/ha)**	**P(kg/ha)**	**Treatment**	**Interval**	**Method**
T_1 (N_1 P_1)	180	25	T_1 (I_1 M_1)	7 days	Flat bed
T_2 (N_1 P_2)	180	50	T_2 (I_1 M_2)	7 days	Ridge and furrow
T_3 (N_1 P_3)	180	75	T_3 (I_1 M_3)	7 days	Alternate furrow
T_4 (N_2 P_1)	240	25	T_4 (I_2 M_1)	14 days	Flat bed
T_5 (N_2 P_2)	240	50	T_5 (I_2 M_2)	14 days	Ridge and furrow
T_6 (N_2 P_3)	240	75	T_6 (I_2 M_3)	14 days	Alternate furrow
T_7 (N_3 P_1)	300	25	T_7 (I_3 M_1)	21 days	Flat bed
T_8 (N_3 P_2)	300	50	T_8 (I_3 M_2)	21 days	Ridge and furrow
T_9 (N_3 P_3)	300	75	T_9 (I_3 M_3)	21 days	Alternate furrow
Note: fertilizers were applied in the form of Urea & SSP			**Note:** Rainfall and rainy days was also being observed during the study period.		

Method of application of fertilizer

The crop was raised after following standard agronomic practices. All fertilizer doses were applied in different plots according to respective treatments. Generally, application of 240 kg nitrogen, 50 kg phosphorus and 150 kg potassium is recommended for optimum yield. Half dose of nitrogen, phosphorus and potassium were applied at the time of sowing. The half of nitrogen was applied in three split and half of phosphorus and potash were applied in one split application.

Method of observation

The observations on aphid index and whitefly number recorded from three leaves representing top, middle and bottom regions of plant from five randomly selected plants in each plot. The data were recorded at weekly interval starting from one week after germination till to removal of crop. Data were statistically analyzed by following standard procedure (Steel and Torrie, 1980) [8].

Sampling technique for aphid index

It was observed that aphids generally sit in an overlapping manner, so it was difficult to take numerical count; hence aphid index was determined visually according to the scoring system given by Patel (1980) [6].

Results and Discussion

Fertilizers levels and irrigation interval as well as methods influenced the population of aphid and white fly, as their interaction was significant. All the doses of nitrogen and phosphorus as well as irrigation interval and methods under study were significantly differed with each other. It indicated that the incidence of aphids and whitefly varied with the varying fertilizer levels and irrigation.

Impact of fertilizers

Aphid

Impact of nitrogen level

Effect of different nitrogen level on aphid population were presented in Table 2. Looking toward the pooled data, it was clearly observed that the level of nitrogen fertilizer was significantly affecting the population of aphid and increasing the aphid population as increasing the rate of nitrogen.

Significantly the highest aphid index was recorded in nitrogen level N_3 (300 kg N /ha) with 2.86 Aphid Index /plant. It was followed by N_2 (240 kg N /ha) with recorded of 2.54 AI /plant. Significantly the lowest aphid index was observed in level N_1 (180 kg N /ha) to the tune of 2.20 aphid index per plant.

Impact of phosphorous level

Impact of different phosphorus level on aphid population were presented in Table 2 and graphically depicted in Figure 8, from the pooled data it was proved that the level of phosphorous was significantly affecting the population of aphid. As the phosphorous level increase, population of aphid also decreases and vice versa.

Significantly the highest aphid index (2.74 AI /plant) was recorded in phosphorus level P_1 (25 kg P_20_5 AI /ha). It was followed by level P_2 (50 kg P_20_5 /ha) (2.54 AI /plant). Significantly the lowest aphid index was observed in P_3 (75 kg P /ha) to the tune of 2.33 aphid index per plant.

Interaction effect

Interaction effect of nitrogen and phosphorus on aphid index was presented in Table 2. It was found that the interaction effect of nitrogen and phosphorus (N X P) found significantly affecting the population of aphid. Interaction effect of nitrogen and Week after Sowing (N x W) found significant. So, it can be said that the trends of effect of level of nitrogen and phosphorus on aphid population was not similar in all weeks after sowing.

Interaction effect of phosphorus and week after sowing (P x W) was found significant so, it can be said that the trend of effect of level of phosphorus on aphid population was not similar in all WAS. As the Interaction of nitrogen, phosphorus and WAS (N x P x W) was found significant which indicate that the effect of nitrogen and phosphorus combination was not similar in all the WAS.

Looking towards result, it was shown that the aphid incidence was increase with level of nitrogen it may be due to higher

nitrogenous fertilizer make plant more succulent, vigorous and parenchymatous tissue become soft so it give more feeding preference, food consumption, survival, growth and reproduction of aphid. Aphid incidence was decreased with level of phosphorus as higher phosphorus give hardiness to plant which increases the resistance towards aphid. The result was closely confirmed with Tan *et al*. (2012), they recorded that aphid density in cotton plants fertilized with 72 kg/ha N was significantly higher than fertilized with 0 and 108 kg/ha N. Compared to cotton plants treated with 23 and 69 kg/ha P, aphid density was higher in cotton plants treated with 46 kg/ha P.

Table 2: Effect of fertilizer on incidence of aphid in Bt cotton

Treatment	Aphid Index /Plant							
	6 WAS	7 WAS	8 WAS	9 WAS	10 WAS	11 WAS	12 WAS	13 WAS
Nitrogen level (N)								
N_1 : 180 kg N /ha	0.62	0.89	1.19	1.46	1.86	2.03	2.47	3.15
N_2 : 240 kg N/ ha	0.85	1.15	1.45	1.70	2.05	2.50	2.85	3.37
N_3 : 300 kg N /ha	1.08	1.41	1.71	1.94	2.23	2.77	3.20	3.63
Phosphorus level (P)								
P_1 : 25 kg P_2O_5 /ha	0.99	1.24	1.54	1.82	2.15	2.64	2.98	3.59
P_2 : 50 kg P_2O_5 /ha	0.85	1.15	1.45	1.70	2.05	2.45	2.85	3.40
P_3 : 75 kg P_2O_5 /ha	0.70	1.06	1.36	1.58	1.94	2.20	2.68	3.17
N x P								
N_1P_1	0.76	1.09	1.22	1.55	1.69	2.30	2.73	3.78
N_1P_2	0.57	0.84	1.14	1.58	2.00	2.29	2.67	3.19
N_1P_3	0.52	0.73	1.19	1.24	1.89	1.50	2.00	2.48
N_2P_1	1.04	1.19	1.49	1.66	2.29	2.66	2.86	3.36
N_2P_2	0.85	1.14	1.40	1.72	1.98	2.40	2.79	3.43
N_2P_3	0.65	1.11	1.46	1.71	1.87	2.43	2.89	3.33
N_3P_1	1.18	1.43	1.89	2.23	2.48	2.96	3.35	3.61
N_3P_2	1.13	1.46	1.81	1.79	2.17	2.66	3.09	3.57
N_3P_3	0.94	1.35	1.43	1.81	2.06	2.69	3.16	3.70
N S.Em.±	0.02	0.03	0.04	0.05	0.05	0.07	0.08	0.11
C. D at 5%	0.05	0.09	0.13	0.15	0.16	0.22	0.23	0.32
P S.Em.±	0.02	0.03	0.04	0.05	0.05	0.07	0.08	0.11
C. D at 5%	0.05	0.09	0.13	0.15	0.16	0.22	0.23	0.32
W S.Em.±	-	-	-	-	-	-	-	-
C. D at 5%	-	-	-	-	-	-	-	-
N x P S.Em.±	0.03	0.05	0.07	0.09	0.09	0.13	0.13	0.19
C. D at 5%	0.09	0.15	0.22	0.26	0.28	0.38	0.40	0.56
N x W S.Em.±	-	-	-	-	-	-	-	-
C. D at 5%	-	-	-	-	-	-	-	-
P x W S.Em.±	-	-	-	-	-	-	-	-
C. D at 5%	-	-	-	-	-	-	-	-
N x P x W S.Em.±	-	-	-	-	-	-	-	-
C. D at 5%	-	-	-	-	-	-	-	-
C. V.%	6.45	7.54	8.65	8.93	8.03	9.11	8.08	9.50

Table 2a: Effect of fertilizer on incidence of aphid in *Bt* cotton

Treatment	Aphid Index /Plant								
	14 WAS	15 WAS	16 WAS	17 WAS	18 WAS	19 WAS	20 WAS	21 WAS	Pooled Mean
Nitrogen level (N)									
N_1 : 180 kg N /ha	3.33	3.90	3.65	3.20	2.59	2.25	1.70	0.97	2.20
N_2 : 240 kg N/ ha	3.72	4.14	4.19	3.70	3.15	2.60	2.15	1.15	2.54
N_3 : 300 kg N /ha	4.06	4.41	4.64	4.15	3.63	2.99	2.64	1.34	2.86
Phosphorus level(P)									
P_1 : 25 kg P_2O_5 /ha	3.89	4.36	4.41	3.90	3.31	2.81	2.35	1.82	2.74
P_2 : 50 kg P_2O_5 /ha	3.75	4.14	4.16	3.69	3.15	2.61	2.15	1.13	2.54
P_3 : 75 kg P_2O_5 /ha	3.47	3.96	3.92	3.46	2.91	2.42	1.99	0.51	2.33
N x P									
N_1P_1	3.64	4.69	4.35	3.77	2.97	2.72	2.72	1.46	2.55
N_1P_2	3.62	3.59	3.64	3.23	2.81	2.21	2.21	0.93	2.24
N_1P_3	2.74	3.43	2.95	2.59	1.99	1.81	1.81	0.54	1.81
N_2P_1	3.77	4.05	4.21	3.74	3.24	2.67	2.67	1.78	2.64
N_2P_2	3.74	4.31	4.20	3.69	3.07	2.61	2.61	1.14	2.54
N_2P_3	3.64	4.08	4.17	3.66	3.13	2.54	2.54	0.52	2.45
N_3P_1	4.26	4.33	4.66	4.19	3.72	3.05	3.05	2.21	3.02
N_3P_2	3.90	4.52	4.65	4.14	3.56	2.99	2.99	1.31	2.84
N_3P_3	4.03	4.37	4.62	4.11	3.63	2.91	2.91	0.49	2.74
N S.Em.±	0.08	0.10	0.12	0.09	0.09	0.07	0.06	0.06	0.02

C. D at 5%	0.25	0.30	0.37	0.28	0.26	0.22	0.17	0.17	0.05
P S.Em.±	0.08	0.10	0.12	0.09	0.09	0.07	0.06	0.06	0.02
C. D at 5%	0.25	0.30	0.37	0.28	0.26	0.22	0.17	0.17	0.05
W S.Em.±	-	-	-	-	-	-	-	-	0.04
C. D at 5%	-	-	-	-	-	-	-	-	0.12
N x P S.Em.±	0.15	0.17	0.21	0.16	0.15	0.13	0.10	0.10	0.03
C. D at 5%	0.44	0.52	0.64	0.49	0.46	0.38	0.30	0.29	0.09
N x W S.Em.±	-	-	-	-	-	-	-	-	0.07
C. D at 5%	-	-	-	-	-	-	-	-	0.20
P x W S.Em.±	-	-	-	-	-	-	-	-	0.07
C. D at 5%	-	-	-	-	-	-	-	-	0.20
N x P x W S.Em.±	-	-	-	-	-	-	-	-	0.13
C. D at 5%	-	-	-	-	-	-	-	-	0.35
C. V.%	6.85	7.23	8.86	7.67	8.44	8.31	8.04	14.50	8.54

Whitefly

Impact of nitrogen level

Effect of different nitrogen level on whitefly population was presented in Table 3. Pooled data showed that there was significant difference in whitefly population at different level of nitrogen.

Significantly higher number of whitefly population was recorded in nitrogen level N_3 (300 kg /ha) with 3.32 whitefly /leaf. It was followed by level N_2 (240 kg N /ha) with 2.77 whitefly /leaf. Significantly lowest whitefly population was observed in level N_1 (180 kg /ha) to the tune of 2.20 whitefly per leaf.

Impact of phosphorus level

Impact of different phosphorus level on whitefly population was presented in Table 3. Pooled data showed that the level of phosphorous fertilizer was significantly affecting the population of whitefly.

Significantly highest whitefly population (3.14 whitefly /leaf) was recorded in phosphorus level P_1 (25 kg P_20_5 /ha). It was followed by level P_2 (50 kg P_20_5 / ha) (2.77 whitefly /leaf). Significantly lowest whitefly population was observed in level P_3 (75 kg P_20_5 /ha) to the tune of 2.38 whitefly per leaf.

Table 3: Effect of fertilizer on incidence of whitefly in *Bt* cotton

Treatment	Whitefly /Leaf							
	6 WAS	7 WAS	8 WAS	9 WAS	10 WAS	11 WAS	12 WAS	13 WAS
Nitrogen level (N)								
N_1 : 180 kg N /ha	1.42 (1.51)	1.49 (1.74)	1.66 (2.27)	1.64 (2.23)	1.76 (2.63)	1.81 (2.85)	1.87 (3.08)	2.00 (3.55)
N_2 : 240 kg N/ ha	1.49 (1.74)	1.55 (1.92)	1.76 (2.62)	1.83 (2.92)	1.89 (3.15)	2.01 (3.63)	2.09 (3.96)	2.19 (4.37)
N_3 : 300 kg N /ha	1.56 (1.95)	1.62 (2.12)	1.87 (3.02)	2.02 (3.62)	2.04 (3.7)	2.17 (4.21)	2.31 (4.84)	2.36 (5.13)
Phosphorus level (P)								
P_1 : 25 kg P_2O_5 /ha	1.54 (1.87)	1.62 (2.14)	1.83 (2.89)	1.95 (3.35)	2.02 (3.59)	2.12 (4.05)	2.24 (4.55)	2.33 (4.96)
P_2 : 50 kg P_2O_5 /ha	1.49 (1.74)	1.55 (1.94)	1.77 (2.64)	1.83 (2.93)	1.89 (3.16)	2.01 (3.64)	2.08 (3.96)	2.16 (4.32)
P_3 : 75 kg P_2O_5 /ha	1.44 (1.59)	1.48 (1.7)	1.69 (2.37)	1.72 (2.49)	1.78 (2.72)	1.85 (3.00)	1.95 (3.37)	2.06 (3.77)
N x P								
N_1P_1	1.48 (1.68)	1.61 (2.08)	1.59 (2.02)	1.78 (2.66)	1.90 (3.10)	2.02 (3.56)	2.04 (3.68)	2.13 (4.06)
N_1P_2	1.35 (1.32)	1.35 (1.33)	1.70 (2.39)	1.47 (1.66)	1.59 (2.03)	1.55 (1.90)	1.65 (2.21)	1.77 (2.64)
N_1P_3	1.42 (1.52)	1.52 (1.80)	1.69 (2.36)	1.68 (2.33)	1.79 (2.69)	1.86 (2.95)	1.93 (3.23)	2.10 (3.92)
N_2P_1	1.61 (2.09)	1.66 (2.26)	1.89 (3.08)	2.05 (3.72)	2.17 (4.19)	2.16 (4.18)	2.41 (5.31)	2.46 (5.56)
N_2P_2	1.49 (1.72)	1.57 (1.97)	1.82 (2.82)	1.86 (2.96)	1.89 (3.08)	2.25 (4.56)	2.11 (3.97)	2.12 (3.98)
N_2P_3	1.37 (1.38)	1.41 (1.50)	1.57 (1.96)	1.58 (2.00)	1.61 (2.09)	1.61 (2.11)	1.74 (2.52)	2.00 (3.49)
N_3P_1	1.52 (1.82)	1.60 (2.05)	2.01 (3.53)	2.01 (3.56)	1.99 (3.44)	2.19 (4.31)	2.26 (4.59)	2.40 (5.25)
N_3P_2	1.63 (2.15)	1.73 (2.50)	1.79 (2.70)	2.15 (4.14)	2.20 (4.32)	2.22 (4.42)	2.48 (5.68)	2.60 (6.25)
N_3P_3	1.54 (1.86)	1.52 (1.80)	1.81 (2.78)	1.91 (3.14)	1.94 (3.28)	2.08 (3.84)	2.18 (4.24)	2.07 (3.80)
N S.Em.±	0.03	0.04	0.04	0.05	0.06	0.07	0.07	0.06
C. D at 5%	0.08	NS	0.12	0.16	0.18	0.20	0.21	0.19
P S.Em.±	0.03	0.04	0.04	0.05	0.06	0.07	0.07	0.06
C. D at 5%	NS	NS	NS	0.16	0.06	0.20	0.21	0.19
W S.Em.±	-	-	-	-	-	-	-	-
C. D at 5%	-	-	-	-	-	-	-	-
N x P S.Em.±	0.05	0.06	0.07	0.09	0.11	0.12	0.12	0.11
C. D at 5%	0.14	0.19	0.21	0.27	0.32	0.35	0.37	0.32
N x W S.Em.±	-	-	-	-	-	-	-	-
C. D at 5%	-	-	-	-	-	-	-	-
P x W S.Em.±	-	-	-	-	-	-	-	-
C. D at 5%	-	-	-	-	-	-	-	-
N x P x W S.Em.±	-	-	-	-	-	-	-	-
C. D at 5%	-	-	-	-	-	-	-	-
C. V.%	5.40	7.17	6.91	8.62	9.73	10.09	10.24	8.54

Notes: WAS= Week after Sowing; NS = Non significant

Table 3a: Effect of fertilizer on incidence of whitefly in Bt cotton

Treatment	Whitefly /Leaf								
	14 WAS	15 WAS	16 WAS	17 WAS	18 WAS	19 WAS	20 WAS	21 WAS	Pooled
Nitrogen level (N)									
N_1 : 180 kg N /ha	1.94 (3.33)	1.83 (2.91)	1.72 (2.48)	1.59 (2.09)	1.43 (1.56)	1.31 (1.23)	1.24 (1.06)	1.09 (0.7)	1.61 (2.20)
N_2 : 240 kg N/ ha	2.14 (4.18)	2 (3.57)	1.89 (3.13)	1.8 (2.82)	1.62 (2.15)	1.48 (1.72)	1.42 (1.55)	1.19 (0.93)	1.77 (2.77)
N_3 : 300 kg N /ha	2.35 (5.04)	2.17 (4.22)	2.06 (3.78)	1.98 (3.45)	1.8 (2.75)	1.63 (2.17)	1.55 (1.93)	1.29 (1.16)	1.92 (3.32)
Phosphorus level (P)									
P_1 : 25 kg P_2O_5 /ha	2.28 (4.72)	2.12 (4.00)	2.00 (3.53)	1.93 (3.27)	1.73 (2.52)	1.58 (2.00)	1.5 (1.78)	1.26 (1.09)	1.88 (3.14)
P_2 : 50 kg P_2O_5 /ha	2.13 (4.18)	1.99 (3.57)	1.89 (3.13)	1.79 (2.82)	1.61 (2.15)	1.47 (1.72)	1.38 (1.49)	1.18 (0.93)	1.76 (2.77)
P_3 : 75 kg P_2O_5 /ha	2.03 (3.65)	1.90 (3.13)	1.79 (2.72)	1.65 (2.27)	1.50 (1.79)	1.37 (1.40)	1.32 (1.27)	1.12 (0.77)	1.67 (2.38)
N x P									
N_1P_1	2.09 (3.89)	1.96 (3.34)	1.82 (2.81)	1.78 (2.67)	1.56 (1.93)	1.5 (1.76)	1.4 (1.46)	1.16 (0.85)	1.74 (2.52)
N_1P_2	1.72 (2.45)	1.65 (2.24)	1.59 (2.02)	1.36 (1.34)	1.34 (1.29)	1.2 (0.95)	1.11 (0.74)	0.99 (0.47)	1.46 (1.64)
N_1P_3	2.01 (3.56)	1.88 (3.03)	1.74 (2.54)	1.63 (2.17)	1.4 (1.47)	1.21 (0.97)	1.2 (0.94)	1.11 (0.74)	1.64 (2.18)
N_2P_1	2.45 (5.48)	2.26 (4.61)	2.12 (4.01)	2.03 (3.61)	1.81 (2.79)	1.69 (2.37)	1.56 (1.94)	1.33 (1.28)	1.98 (3.42)
N_2P_2	2.15 (4.12)	2.01 (3.56)	1.9 (3.12)	1.92 (3.2)	1.63 (2.15)	1.46 (1.62)	1.31 (1.22)	1.2 (0.93)	1.79 (2.72)
N_2P_3	1.83 (2.84)	1.74 (2.52)	1.66 (2.24)	1.44 (1.58)	1.42 (1.51)	1.28 (1.15)	1.4 (1.46)	1.03 (0.56)	1.54 (1.88)
N_3P_1	2.29 (4.75)	2.13 (4.05)	2.05 (3.72)	1.99 (3.47)	1.83 (2.84)	1.54 (1.86)	1.55 (1.9)	1.27 (1.11)	1.91 (3.16)
N_3P_2	2.52 (5.83)	2.3 (4.79)	2.17 (4.22)	2.08 (3.82)	1.88 (3.02)	1.75 (2.56)	1.73 (2.48)	1.37 (1.37)	2.04 (3.65)
N_3P_3	2.24 (4.5)	2.07 (3.77)	1.96 (3.35)	1.87 (2.99)	1.69 (2.34)	1.6 (2.06)	1.37 (1.38)	1.22 (1.00)	1.82 (2.80)
N S.Em.±	0.07	0.06	0.05	0.06	0.03	0.04	0.05	0.03	0.01
C. D at 5%	0.20	0.17	0.14	0.17	0.08	0.12	0.14	0.10	0.04
P S.Em.±	0.07	0.06	0.05	0.06	0.03	0.04	0.05	0.03	0.01
C. D at 5%	0.20	0.17	0.14	0.17	0.08	0.12	0.14	0.10	0.04
W S.Em.±	-	-	-	-	-	-	-	-	0.03
C. D at 5%	-	-	-	-	-	-	-	-	0.08
N x P S.Em.±	0.11	0.10	0.08	0.10	0.05	0.07	0.08	0.06	0.02
C. D at 5%	0.34	0.30	0.25	0.30	0.14	0.22	0.23	0.18	0.06
N x W S.Em.±	-	-	-	-	-	-	-	-	0.051
C. D at 5%	-	-	-	-	-	-	-	-	NS
P x W S.Em.±	-	-	-	-	-	-	-	-	0.051
C. D at 5%	-	-	-	-	-	-	-	-	NS
N x P x W S.Em.±	-	-	-	-	-	-	-	-	0.089
C. D at 5%	-	-	-	-	-	-	-	-	NS
C. V.%	9.13	8.68	7.57	9.65	5.15	8.49	9.65	8.68	8.67

Notes: WAS= Week after Sowing; NS = Non significant

Interaction effect

Interaction effect on whitefly population presented in Table 3. Looking towards the pooled data, it was found that the interaction of nitrogen and phosphorus (N x P) was found significant. Interaction effect of nitrogen and different Week after Sowing (N x W) found non significant. So, it can be said that the trend of effect of different level of nitrogen in different Week after sowing was similar. Interaction of phosphorus and WAS (P x W) was found significant, which indicate that the effect of phosphorus on whitefly population was not similar in all the WAS. Interaction of nitrogen, phosphorus and WAS (N x P x W) was found non significant which indicating consistent performance of interaction during entire season.

From above mentioned result, it can be said that whitefly incidence increased with level of nitrogen because higher nitrogenous fertilizer makes plant more succulent, vigorous and parenchymatous tissue become soft. It gives more feeding preference, food consumption, survival, growth and reproduction of whitefly. Whitefly incidence decreased with level of phosphorus as higher phosphorus gives hardiness to plant which increase the resistance towards whitefly. These was due to higher amount of nitrogen fertilizer make plant more succulent. Plant became juicier which was attracting the plant sap sucking insect. The result was closely confirmed with those of Shah *et al*. (2015) [7] noted that application of 360 kg N/ha, higher dose, enhanced the activity of sucking pests.

Yield

Effect of nitrogen

Impact of different nitrogen level on cotton yield were presented in Table 4. Looking toward the data, it was clearly observed that the level of nitrogenous fertilizer was significantly affecting the cotton yield. Among the different nitrogen level, N_3 (300 kg N/ha) registered significantly higher yield (28.31 q /ha) which was followed by N_2 (240 kg N /ha) (27.15 q /ha). While N_1 (180 kg N/ha) was recorded significantly lower cotton yield (19.69 q /ha) as compare to the other treatment.

Effect of phosphorus

Impacts of different phosphorous level on cotton yield were presented in Table 4. From the data, it was clearly observed that the level of phosphorous fertilizer was significantly affecting the cotton yield. Among the different Phosphorous level, P_2 (50 kg P_2O_5 /ha) registered with significantly higher yield (26.16 q /ha) which was followed by P_3 (75 kg P_2O_5 /ha) (25.72 q/ha). While, P_1 (25 kg P_2O_5 /ha) was recorded significantly lower cotton yield (23.26 q /ha).

Table 4: Effect of fertilizer on yield of *Bt* cotton

Treatment	Cotton yield (q /ha)
Nitrogen Level (N)	
N_1 : 180 kg N/ha	19.69
N_2 : 240 kg N/ha	27.15
N_3 : 300 kg N/ha	28.31
S.Em. ±	0.80
C.D. @ 5%	2.39
Phosphorous Level (P)	
Treatment	**Cotton yield (q /ha)**
P_1 : 25 kg P_2O_5/ha	23.26
P_2 : 50 kg P_2O_5/ha	26.16
P_3 : 75 kg P_2O_5/ha	25.72
S.Em. ±	0.80
C.D. @ 5%	2.39
Interaction Effect (N X P)	
N_1P_1	17.97
N_1P_2	16.20
N_1P_3	24.91
N_2P_1	31.66
N_2P_2	27.23
N_2P_3	22.57
N_3P_1	20.18
N_3P_2	35.07
N_3P_3	29.69
S.Em. ±	1.39
C.D. @ 5%	4.15
C.V. %	9.58

Interaction effect

Interaction effect on whitefly population presented in Table 4. Looking towards the pooled data, it was found that the interaction of nitrogen and phosphorus (N x P) was found significant. Earlier, Gupta and Ram (2008) [5] reported that seed production was increased with higher doses of nitrogen and phosphorus fertilizers. So, the results obtained in the present investigation are said to be in agreement with those of earlier reports.

Impact of Irrigation Interval and Methods

Aphid

Effect of Irrigation interval

Effect of different irrigation intervals on aphid index per plant were presented in Table 5. Looking toward the data, it was clearly observed that the irrigation interval was significantly affecting the population of aphid.

Among the different irrigation interval I_3 (21 days irrigation interval) registered significantly lowest aphid population with 2.30 Aphid index /plant. Which was followed by I_2 (14 days irrigation interval) which is registered with 2.63 Aphid index /plant. While, I_1 (7 days irrigation interval) was recorded higher number of aphid population with 2.83 Aphid index /plant.

Effect of Irrigation method

Effect of different irrigation methods on aphid were presented in Table 5. Looking toward the data, it was clearly observed that the irrigation method was significantly affecting the population of aphid.

Among the different irrigation method M_2 (Ridge and Furrow) registered significantly lover number of aphid population with 2.23 Aphid index per plant, which was followed by M_3 (Alternate Furrow) (2.65 AI /plant). While, M_1 (Flat bed) was recorded higher number of aphid population with 2.86 Aphid index per plant.

Interaction Effect

Interaction effects of different irrigation interval and irrigation methods on aphid were presented in Table 5. Looking toward the data, it was clearly observed that the interaction effect of different irrigation intervals and irrigation methods were significantly affecting the population of aphid in *Bt* cotton during *kharif*, 2018.

Table 5: Effect of irrigation on aphid incidence in Bt cotton

Treatment	Aphid index /plant							
	6 WAS	7 WAS	8 WAS	9 WAS	10 WAS	11 WAS	12 WAS	13 WAS
Irrigation interval (I)								
I_1 : 7 days	1.22	1.24	1.37	1.76	2.47	2.72	3.34	3.79
I_2 : 14 days	1.18	1.13	1.27	1.63	2.26	2.58	3.09	3.59
I_3 : 21 days	1.07	0.94	1.11	1.43	1.88	2.35	2.74	3.28
Irrigation method (M)								
M_1 : Flat bed	1.20	1.25	1.42	1.77	2.47	2.70	3.35	3.93
M_2 : Ridge and Furrow	1.10	0.91	1.04	1.38	1.87	2.35	2.67	3.09
M_3 : Alternate Furrow	1.17	1.14	1.29	1.66	2.27	2.60	3.15	3.63
I X M								
I_1M_1	1.31	1.49	1.67	2.14	2.93	3.04	4.00	4.46
I_1M_2	1.08	0.86	0.95	1.13	1.80	2.15	2.22	2.87
I_1M_3	1.29	1.35	1.49	2.02	2.68	2.96	3.80	4.03
I_2M_1	1.21	1.28	1.44	1.78	2.53	2.74	3.35	3.99
I_2M_2	1.13	0.94	1.05	1.42	1.92	2.41	2.76	3.09
I_2M_3	1.19	1.17	1.31	1.67	2.32	2.60	3.16	3.69
I_3M_1	1.08	0.98	1.16	1.40	1.96	2.33	2.70	3.35
I_3M_2	1.10	0.94	1.12	1.60	1.87	2.50	3.03	3.31
I_3M_3	1.04	0.90	1.06	1.28	1.81	2.22	2.49	3.18
I S.Em.±	0.01	0.05	0.05	0.07	0.08	0.06	0.12	0.09
C. D at 5%	0.05	0.19	NS	NS	0.32	0.25	NS	0.36
C. V.%	3.57	12.89	12.27	12.60	11.21	7.42	11.80	7.68
M S.Em.±	0.02	0.05	0.05	0.08	0.08	0.07	0.13	0.12
C. D at 5%	0.06	0.15	0.17	0.24	0.27	0.22	0.42	0.39
C. V.%	4.63	12.12	12.22	11.60	10.86	7.34	11.15	9.38

W S.Em.±	-	-	-	-	-	-	-	-
C. D at 5%	-	-	-	-	-	-	-	-
I X M S.Em.±	0.03	0.08	0.09	0.13	0.14	0.12	0.23	0.21
C. D at 5%	0.11	0.27	0.30	0.42	0.46	0.38	0.74	0.68
I X W S.Em.±	-	-	-	-	-	-	-	-
C. D at 5%	-	-	-	-	-	-	-	-
M X W S.Em.±	-	-	-	-	-	-	-	-
C. D at 5%	-	-	-	-	-	-	-	-
I X M X W S.Em.±	-	-	-	-	-	-	-	-
C. D at 5%	-	-	-	-	-	-	-	-
C. V.%	4.98	12.78	12.74	14.03	11.16	7.86	12.79	10.23

Table 5a: Effect of irrigation on aphid incidence in *Bt* cotton

Treatment	Aphid index /plant								
	14 WAS	15 WAS	16 WAS	17 WAS	18 WAS	19 WAS	20 WAS	21 WAS	Pooled
Irrigation interval (I)									
I_1 : 7 days	4.12	4.56	4.71	4.02	3.49	3.01	2.22	1.19	2.83
I_2 : 14 days	3.90	4.25	4.39	3.73	3.26	2.80	1.98	1.05	2.63
I_3 : 21 days	3.54	3.78	3.82	3.21	2.86	2.44	1.51	0.77	2.30
Irrigation method (M)									
M_1 : Flat bed	4.24	4.73	4.76	4.06	3.57	3.09	2.13	1.15	2.86
M_2 : Ridge and Furrow	3.38	3.55	3.74	3.15	2.75	2.33	1.61	0.82	2.23
M_3 : Alternate Furrow	3.94	4.32	4.41	3.75	3.29	2.83	1.97	1.04	2.65
I X M									
I_1M_1	4.77	5.50	5.48	4.72	4.11	3.60	2.60	1.43	3.32
I_1M_2	3.17	3.31	3.59	3.03	2.61	2.19	1.63	0.83	2.09
I_1M_3	4.43	4.88	5.05	4.32	3.74	3.25	2.43	1.32	3.07
I_2M_1	4.31	4.81	4.85	4.13	3.66	3.14	2.20	1.19	2.91
I_2M_2	3.42	3.58	3.82	3.22	2.76	2.37	1.71	0.88	2.28
I_2M_3	3.97	4.37	4.50	3.84	3.36	2.88	2.03	1.07	2.70
I_3M_1	3.63	3.89	3.94	3.32	2.94	2.54	1.60	0.82	2.35
I_3M_2	3.56	3.76	3.82	3.21	2.87	2.43	1.50	0.76	2.34
I_3M_3	3.42	3.69	3.69	3.10	2.76	2.36	1.44	0.73	2.20
I S.Em.±	0.11	0.14	0.14	0.13	0.11	0.10	0.06	0.04	0.20
C. D at 5%	0.42	0.55	0.56	0.50	0.45	0.40	0.22	0.15	0.56
C. V.%	8.25	9.93	9.89	10.42	10.68	11.15	9.00	11.18	2.18
M S.Em.±	0.12	0.16	0.14	0.12	0.11	0.10	0.07	0.04	0.20
C. D at 5%	0.40	0.51	0.46	0.41	0.37	0.33	0.22	0.14	0.56
C. V.%	8.78	11.28	9.31	9.84	10.40	11.35	9.85	11.75	10.78
W S.Em.±	-	-	-	-	-	-	-	-	0.45
C. D at 5%	-	-	-	-	-	-	-	-	1.30
I X M S.Em.±	0.21	0.27	0.24	0.22	0.20	0.18	0.12	0.07	0.34
C. D at 5%	0.70	0.88	0.80	0.70	0.64	0.58	0.39	0.24	0.98
I X W S.Em.±	-	-	-	-	-	-	-	-	0.78
C. D at 5%	-	-	-	-	-	-	-	-	2.26
M X W S.Em.±	-	-	-	-	-	-	-	-	0.78
C. D at 5%	-	-	-	-	-	-	-	-	2.26
I X M X W S.Em.±	-	-	-	-	-	-	-	-	1.35
C. D at 5%	-	-	-	-	-	-	-	-	3.91
C. V.%	9.61	11.11	9.83	10.23	10.61	11.15	10.83	12.92	11.36

By observing the data presented in Table 5 it was shows that the aphid incidence was increase with the shorter irrigation interval. The population of aphid was negatively correlated with irrigation interval. It may be due to shorter irrigation interval make plant more vigorous and juicy which make plant more succulent and provide favourable condition for aphid and whitefly. Plant became more juicier which was attracting the plant sap sucking insect. The result was closely confirmed with those of Badenhausser *et al*. (1994) [3] noted that the infestation of aphid was more in short interval while more aphid in stress on alfalfa plant.

Whitefly

Effect of Irrigation interval

Effect of different irrigation interval on whitefly population were presented in Table 6 was indicated that the irrigation interval was significantly affecting the population of whitefly. In that long irrigation interval found less population of whitefly in cotton. While, in shorter interval increase the population of whitefly.

Among the different irrigation interval I_3 (21 days irrigation interval) recorded significantly lower number of whitefly population (3.04 whitefly /leaf) which was followed by I_2 (14 days irrigation interval) recorded with 4.32 whitefly /leaf. In

case of 7 days irrigation interval (I_1) was found significantly higher number of whitefly population (4.99 whitefly /leaf).

Effect of Irrigation methods

Effect of different irrigation methods on whitefly population were presented in Table 6 was indicated that the irrigation method was significantly affecting the population of whitefly. In that M2 (Ridge and furrow) found lowest population with recorded 2.32 whitefly per leaf followed by M3 (Alternate furrow) registered with 2.91 whitefly per leaf. Highest population of whitefly was found in flat bed (M1) method (3.16 whitefly /leaf).

Interaction Effect

Interaction effects of different irrigation intervals and irrigation methods on whitefly population was presented in Table 6. Looking toward the data, it was clearly observed that the interaction effect of different irrigation intervals and irrigation methods was found significantly affecting the population of whitefly in cotton.

Table 6: Effect of irrigation on incidence of whitefly in *Bt* cotton

Treatment	Whitefly /leaf							
	6 WAS	7 WAS	8 WAS	9 WAS	10 WAS	11 WAS	12 WAS	13 WAS
Irrigation interval (I)								
I_1 : 7 days	1.52 (1.80)	1.60 (2.06)	1.78 (2.69)	2.03 (3.66)	1.96 (3.38)	2.18 (4.3)	2.41 (5.39)	2.49 (5.76)
I_2 : 14 days	1.48 (1.71)	1.58 (2.01)	1.71 (2.42)	1.92 (3.21)	1.88 (3.05)	2.08 (3.84)	2.24 (4.53)	2.35 (5.02)
I_3 : 21 days	1.41 (1.50)	1.54 (1.88)	1.56 (1.93)	1.70 (2.41)	1.73 (2.50)	1.86 (2.98)	1.85 (2.92)	2.03 (3.63)
Irrigation method (M)								
M_1 : Flat bed	1.50 (1.75)	1.59 (2.03)	1.76 (2.64)	2.00 (3.54)	1.95 (3.35)	2.15 (4.16)	2.31 (4.91)	2.43 (5.45)
M_2 : Ridge and Furrow	1.44 (1.58)	1.56 (1.93)	1.58 (1.99)	1.74 (2.52)	1.74 (2.53)	1.91 (3.15)	1.97 (3.42)	2.11 (3.96)
M_3 : Alternate Furrow	1.48 (1.69)	1.58 (2.00)	1.70 (2.42)	1.92 (3.21)	1.88 (3.06)	2.07 (3.83)	2.21 (4.51)	2.33 (5.00)
I X M								
I_1M_1	1.55 (1.89)	1.62 (2.11)	1.91 (3.17)	2.21 (4.39)	2.13 (4.02)	2.35 (5.04)	2.62 (6.38)	2.70 (6.81)
I_1M_2	1.47 (1.67)	1.57 (1.98)	1.58 (1.99)	1.75 (2.57)	1.74 (2.52)	1.93 (3.21)	2.05 (3.70)	2.15 (4.13)
I_1M_3	1.53 (1.84)	1.61 (2.08)	1.85 (2.91)	2.12 (3.99)	2.02 (3.59)	2.27 (4.65)	2.56 (6.07)	2.61 (6.33)
I_2M_1	1.51 (1.78)	1.59 (2.04)	1.79 (2.70)	2.03 (3.63)	1.98 (3.41)	2.18 (4.27)	2.36 (5.08)	2.47 (5.62)
I_2M_2	1.45 (1.61)	1.56 (1.94)	1.60 (2.07)	1.78 (2.67)	1.76 (2.62)	1.95 (3.30)	2.08 (3.82)	2.18 (4.26)
I_2M_3	1.49 (1.72)	1.59 (2.01)	1.73 (2.49)	1.95 (3.32)	1.90 (3.13)	2.11 (3.94)	2.28 (4.68)	2.38 (5.16)
I_3M_1	1.43 (1.55)	1.55 (1.91)	1.59 (2.03)	1.75 (2.58)	1.76 (2.59)	1.91 (3.14)	1.94 (3.26)	2.10 (3.91)
I_3M_2	1.39 (1.43)	1.53 (1.84)	1.55 (1.89)	1.68 (2.31)	1.71 (2.44)	1.85 (2.92)	1.79 (2.70)	1.99 (3.48)
I_3M_3	1.41 (1.49)	1.54 (1.88)	1.54 (1.87)	1.68 (2.31)	1.72 (2.45)	1.84 (2.87)	1.81 (2.76)	1.99 (3.47)
I S.Em.±	0.02	0.02	0.02	0.03	0.03	0.03	0.02	0.03
C. D at 5%	NS	NS	0.09	0.11	0.10	0.10	0.09	0.11
C. V.%	4.55	4.28	3.87	4.46	4.25	3.68	3.05	3.66
M S.Em.±	0.05	0.05	0.02	0.03	0.03	0.03	0.04	0.04
C. D at 5%	NS	NS	0.08	0.10	0.09	0.10	0.13	0.13
C. V.%	4.97	4.41	4.53	5.67	4.81	4.68	4.93	5.20
W S.Em.±	-	-	-	-	-	-	-	-
C. D at 5%	-	-	-	-	-	-	-	-
I X M S.Em.±	0.08	0.08	0.04	0.06	0.05	0.05	0.07	0.07
C. D at 5%	NS	NS	0.14	0.18	0.15	0.17	0.23	0.22
I X W S.Em.±	-	-	-	-	-	-	-	-
C. D at 5%	-	-	-	-	-	-	-	-
M X W S.Em.±	-	-	-	-	-	-	-	-
C. D at 5%	-	-	-	-	-	-	-	-
I X M X W S.Em.±	-	-	-	-	-	-	-	-
C. D at 5%	-	-	-	-	-	-	-	-
C. V.%	9.54	8.76	4.30	5.09	4.34	4.53	5.55	5.08

Notes: WAS= Week after Sowing; Figures in the parenthesis indicate retransformed values, while outside are SQRT (X+0.5) transformed values; NS = Non significant

Table 6a: Effect of irrigation on incidence of whitefly in *Bt* cotton

Treatment	Whitefly /leaf								
	14 WAS	15 WAS	16 WAS	17 WAS	18 WAS	19 WAS	20 WAS	21 WAS	Pooled
Irrigation interval (I)									
I_1 : 7 days	2.33 (4.99)	2.18 (4.3)	2.01 (3.57)	2.01 (3.62)	1.92 (3.23)	1.62 (2.16)	1.48 (1.71)	1.25 (1.08)	2.33 (4.99)
I_2 : 14 days	2.19 (4.32)	2.07 (3.79)	1.9 (3.11)	1.86 (2.97)	1.77 (2.65)	1.51 (1.79)	1.38 (1.4)	1.19 (0.91)	2.19 (4.32)
I_3 : 21 days	1.88 (3.04)	1.82 (2.81)	1.65 (2.24)	1.52 (1.82)	1.44 (1.6)	1.28 (1.13)	1.16 (0.85)	1.05 (0.61)	1.88 (3.04)
Irrigation method (M)									
M_1 : Flat bed	2.26 (4.66)	2.12 (4.03)	1.96 (3.37)	1.93 (3.3)	1.83 (2.91)	1.56 (1.97)	1.42 (1.55)	1.22 (1.01)	1.87 (3.16)
M_2 : Ridge and Furrow	1.97 (3.39)	1.9 (3.11)	1.72 (2.46)	1.61 (2.12)	1.54 (1.9)	1.35 (1.32)	1.22 (1)	1.08 (0.67)	1.65 (2.32)
M_3 : Alternate Furrow	2.17 (4.29)	2.05 (3.76)	1.88 (3.09)	1.84 (2.99)	1.76 (2.66)	1.5 (1.79)	1.37 (1.41)	1.18 (0.91)	1.81 (2.91)
I X M									
I_1M_1	1.55 (1.89)	1.62 (2.11)	1.91 (3.17)	2.21 (4.39)	2.13 (4.02)	2.35 (5.04)	2.62 (6.38)	2.70 (6.81)	2.52 (5.86)
I_1M_2	1.47 (1.67)	1.57 (1.98)	1.58 (1.99)	1.75 (2.57)	1.74 (2.52)	1.93 (3.21)	2.05 (3.70)	2.15 (4.13)	2.02 (3.58)
I_1M_3	1.53 (1.84)	1.61 (2.08)	1.85 (2.91)	2.12 (3.99)	2.02 (3.59)	2.27 (4.65)	2.56 (6.07)	2.61 (6.33)	2.45 (5.50)
I_2M_1	1.51 (1.78)	1.59 (2.04)	1.79 (2.70)	2.03 (3.63)	1.98 (3.41)	2.18 (4.27)	2.36 (5.08)	2.47 (5.62)	2.30 (4.81)
I_2M_2	1.45 (1.61)	1.56 (1.94)	1.60 (2.07)	1.78 (2.67)	1.76 (2.62)	1.95 (3.30)	2.08 (3.82)	2.18 (4.26)	2.04 (3.68)
I_2M_3	1.49 (1.72)	1.59 (2.01)	1.73 (2.49)	1.95 (3.32)	1.90 (3.13)	2.11 (3.94)	2.28 (4.68)	2.38 (5.16)	2.22 (4.45)
I_3M_1	1.43 (1.55)	1.55 (1.91)	1.59 (2.03)	1.75 (2.58)	1.76 (2.59)	1.91 (3.14)	1.94 (3.26)	2.10 (3.91)	1.95 (3.30)
I_3M_2	1.39 (1.43)	1.53 (1.84)	1.55 (1.89)	1.68 (2.31)	1.71 (2.44)	1.85 (2.92)	1.79 (2.70)	1.99 (3.48)	1.84 (2.90)
I_3M_3	1.41 (1.49)	1.54 (1.88)	1.54 (1.87)	1.68 (2.31)	1.72 (2.45)	1.84 (2.87)	1.81 (2.76)	1.99 (3.47)	1.84 (2.90)
I S.Em.±	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.053
C. D at 5%	0.09	0.07	0.08	0.09	0.07	0.06	0.05	0.05	0.153
C. V.%	3.23	2.57	3.36	3.83	3.32	3.05	3.07	3.23	0.324
M S.Em.±	0.04	0.03	0.03	0.04	0.04	0.02	0.03	0.02	0.053
C. D at 5%	0.12	0.09	0.10	0.13	0.12	0.08	0.08	0.05	0.153
C. V.%	4.79	3.55	4.78	5.98	5.16	5.04	4.69	4.57	3.664
W S.Em.±	-	-	-	-	-	-	-	-	0.123
C. D at 5%	-	-	-	-	-	-	-	-	0.354
I X M S.Em.±	0.06	0.05	0.05	0.07	0.06	0.04	0.04	0.03	0.092
C. D at 5%	0.20	0.16	0.17	0.23	0.21	0.14	0.14	0.09	0.266
I X W S.Em.±	-	-	-	-	-	-	-	-	0.213
C. D at 5%	-	-	-	-	-	-	-	-	0.614
M X W S.Em.±	-	-	-	-	-	-	-	-	0.213
C. D at 5%	-	-	-	-	-	-	-	-	0.614
I X M X W S.Em.±	-	-	-	-	-	-	-	-	0.368
C. D at 5%	-	-	-	-	-	-	-	-	1.063
C. V.%	4.96	4.23	4.75	6.82	6.52	5.09	5.69	4.23	5.46

Notes: WAS= Week after Sowing; Figures in the parenthesis indicate retransformed values, while outside are SQRT (X+0.5) transformed values; NS = Non significant

By observing the data presented in Table 6 and 7 it was shows that the aphid and whitefly incidence was increase with the shorter irrigation interval. The population of aphid and whitefly was negatively correlated with irrigation interval. It may be due to shorter irrigation interval make plant more vigorous and juicy which make plant more succulent and provide favourable condition for aphid and whitefly. Plant became more juicier which was attracting the plant sap sucking insect. The result was closely confirmed with those of Badenhausser *et al*. (1994) [3] noted that the infestation of aphid was more in short interval while more aphid in stress on alfalfa plant.

Yield

Effect of Irrigation interval on yield

Impacts of different irrigation interval on cotton yield were presented in Table 7 showed that the irrigation interval was significantly affecting the cotton yield by reducing the damage of aphid and whitefly.

Among the different irrigation interval, I_1 (7 days irrigation

interval) registered significantly higher yield (26.72 q /ha) which, was followed by I_2 (14 days irrigation interval) (23.16 q /ha). While I_3 (21 days irrigation interval) was recorded significantly lower cotton yield (20.51 q /ha).

Effect of Irrigation methods on yield

Impacts of different irrigation methods on cotton yield were presented in Table 7 showed that the irrigation methods was significantly affecting the cotton yield.

Among the different irrigation methods, M_1 (Flat bed) recorded significantly higher cotton yield (24.45 q/ha), which was followed by M_3 (Alternate Furrow) (22.40 q/ha). While, M_2 (Ridge and Furrow) was recorded lowest cotton yield (17.86 q/ha).

Table 7: Effect of irrigation on yield of *Bt* cotton

Treatment	Yield (q /ha)
Irrigation interval (I)	
I_1 : 7 days	26.72
I_2 : 14 days	23.16
I_3 : 21 days	20.51
S.Em. ±	0.51
C.D. @ 5%	2.03
C.V. %	7.21
Irrigation method (M)	
M_1 : Flat bed	24.45
M_2 : Ridge and Furrow	17.86
M_3 : Alternate Furrow	22.40
S.Em. ±	0.64
C.D. @ 5%	2.11
C.V. %	7.21
Interaction Effect (I X M)	
I_1M_1	30.65
I_1M_2	20.47
I_1M_3	29.05
I_2M_1	26.19
I_2M_2	19.37
I_2M_3	23.92
I_3M_1	16.51
I_3M_2	13.74
I_3M_3	14.24
S.Em. ±	1.12
C.D. @ 5%	3.65
C.V. %	9.01

Interaction Effect

Interaction effects of different irrigation intervals and irrigation methods on aphid and whitefly on cotton yield was presented in Table 7. Looking toward the data, it was clearly observed that the interaction effect of different irrigation intervals and irrigation methods was significantly affecting the cotton yield.

The treatment combination I_1M_1 (7 days + flat bed) found highest yield of cotton registered with 30.65 q /ha cotton yield followed by I_1M_3 (7 days + Alternate furrow) recorded 29.05 q /ha cotton yield. However, I_2M_1 (14 days + Flat bed) recorded 26.19 q /ha, which is followed by I_2M_3 (14 days + Alternate furrow), I_1M_2 (7 days + Ridge and furrow) and I_2M_2 (14 days + Ridge and furrow) with 23.92, 20.47 and 19.37 q /ha cotton yield respectively. While, I_3M_1 (21days + Flat bed), I_3M_3 (21 days + Alternate Furrow) and I_3M_2 (21 days + Ridge and furrow) registered with 16.51, 14.24 and 13.74 q /ha cotton yield, respectively.

By observing the data presented in Table 7 indicated that the more irrigation give good groth of plant and it yield better then water stress plant. The result was closely confirmed with Galil *et al.* (2007) [4] observed that the more irrigation plot have higher yield than the non irrigated plot.

Conclusion

Fertilizer levels and irrigation interval as well as methods has significant impact on the population of aphid and whitefly in Bt cotton. Aphid and whitefly incidence is increased with increasing level of nitrogenous fertilizer and decreasing the level of phosphorus. Irrigation should be given at big interval (21 days) and with ridge and furrow method to reduce aphid and whitefly incidence. It is required to follow proper irrigation interval as well as methods and fertilizers levels precisely in Bt cotton to economically manage aphid and whitefly population.

References

1. Anonymous. Species of cotton and insect pest infesting cotton, The cotton corporation of India Ltd. [Source: Cotton Advisory Board (CAB)]; c2016. Retrieved on 13/07/2018 [https://cotcorp.org.in/statistics.aspx#area].
2. Anonymous. Area, production and productivity of cotton in India, The cotton corporation of India Ltd.[Source: Cotton Advisory Board (CAB)]; c2018. Retrieved on 21/06/2018 [https://cotcorp.org.in/statistics.aspx#area].
3. Badenhausser I, Rene BI, Renaud D, Jean LD, Jacques L. Pea aphid (Homoptera: Aphididae) and water deficit interaction on alfalfa stem growth, Journal of Economic Entomology. 1994;87(6):1689-1695.
4. Galil Abdel FA, Amro MA, Abdel M, Moniem AS. Effect of drought stress on the incidence of certain arthropod pests and predators inhabiting cowpea plantations, Archives of Phytopathology and Plant Protection. 2007;40(3):123-125.
5. Gupta MP, Ram S. Effect of nitrogen, phosphorus and potassium on the population of insect pests of fodder mustard (*Brassica campestris* L.) and its seed yield in India, Tropical Pest Management. 2008;34(4):435-437.
6. Patel AM. Biology and control of mustard aphid, (*Lipaphis erysimi* Kalt.) in Saurastra region of Gujarat State. M. Sc. (Agri) Thesis (Unpublished). Gujarat Agricultural University, Sardar Krushi Nagar; c1980. p. 40.
7. Singh U, IfraZoomi OA, Pandey D, Chaudhary KL, Kaur H. Studied the impact of Bt-cotton cultivation of rhizospheric and non-rhizospheric bacterial and fungal population in contrast to non Bt-cotton in natural system.. Volume. 2022;7:135-42.
8. Steel RD, Torrie JH. Principles and procedures of statistics. Publication McGraw-Hill Book Company, New York; c1980. p. 137.
9. Tan Z, Ai T, Lu X, Cai Q, Liu C. Influences of soil fertility on spatial patterns of *Aphis gossypii* Glover (Homoptera: Aphididae) occurred in *Bt*-cotton plants. Advance Journal of Food Science and Technology. 2012;4(6):377-382.
10. Thakare KR, Borle MN, Ajri DS, Gawande RB, Satpute US. Twenty-five years of research on cotton, Pest Management in Maharashtra, Directorate of Research MPKV, Rahuri, India; c1983. p.1-15.
11. Shah KD, Patel CK, Bharpoda TM, Zala MB. Impact of plant spacing and nitrogenous fertilizer on incidence of sucking pests in Bt cotton, International Journal of Plant Protection Volume. 2015;8(1):34-40.